Next Generation Integrated Mobility:

Driving Smart Cities

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Evaluation of Freeway Merging Assistance System Using Driving Simulator

Driving Simulator Overview

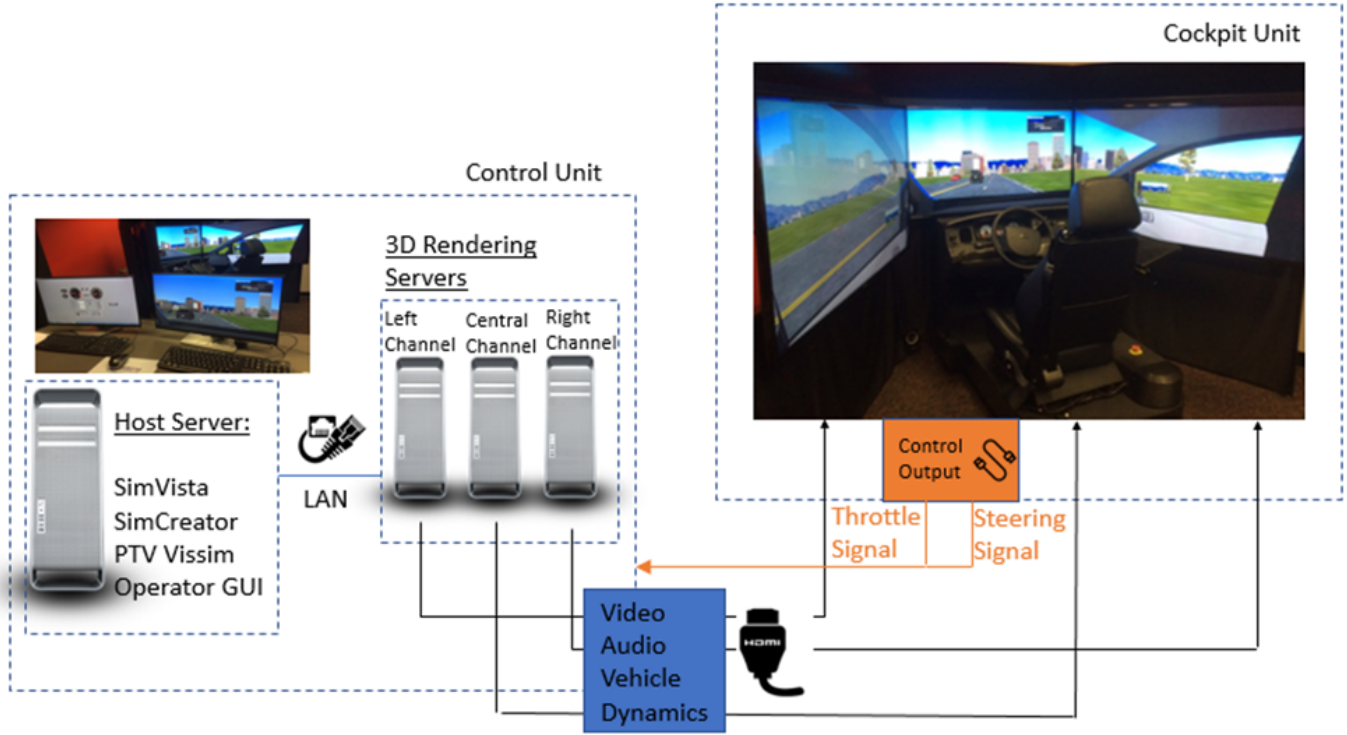
Benefits of using driving simulators:

- Test autonomous and connected vehicle (CV) applications before creating costly prototypes.
- Evaluate human interaction with autonomous and CV vehicles
- Test algorithms used in the programming of the autonomous vehicle

Driving Simulator Overview (continued)

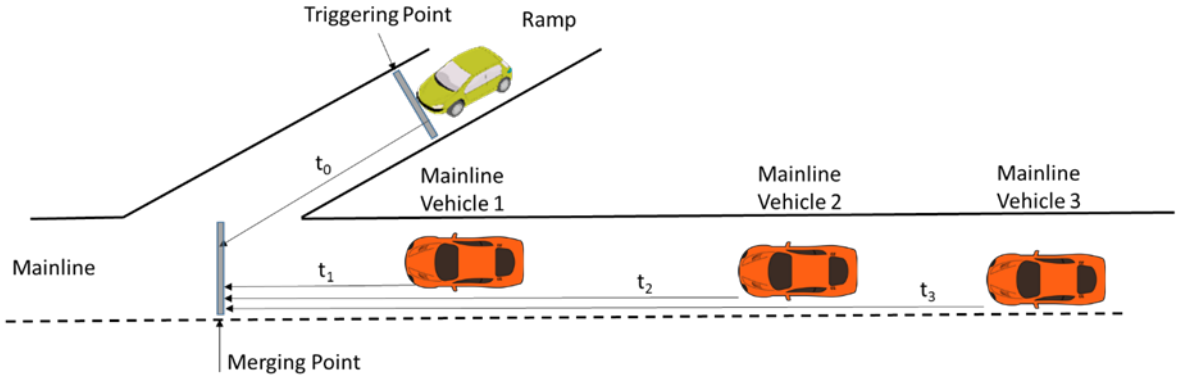
- Programming interface to integrate a microscopic traffic simulator (i.e., **PTV Vissim**)
- Handling the wide variety of simulation environments:
  - Traffic signal and signage location, shape, caption, color, and dimensions
  - Various traffic signal control logics and sensing devices
  - Ambient traffic volume
  - Various vehicle types (e.g. passenger car, bus, truck, tractor-trailer, etc.)
  - Weather condition (rain, fog, snow)
  - Illumination condition (daytime, nighttime)
  - Real-time interactions with background traffic

Driving Simulator Arhitecture

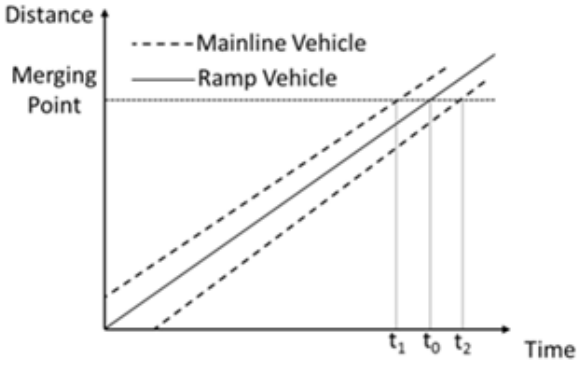


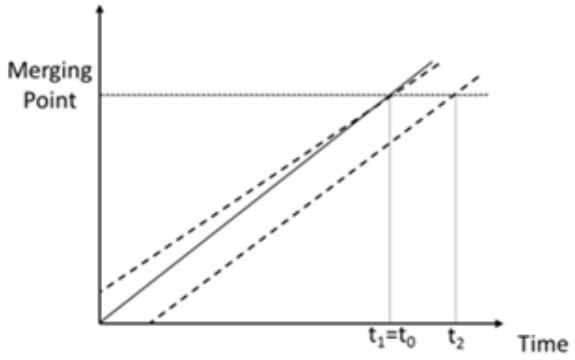
Freeway Merge Assistance

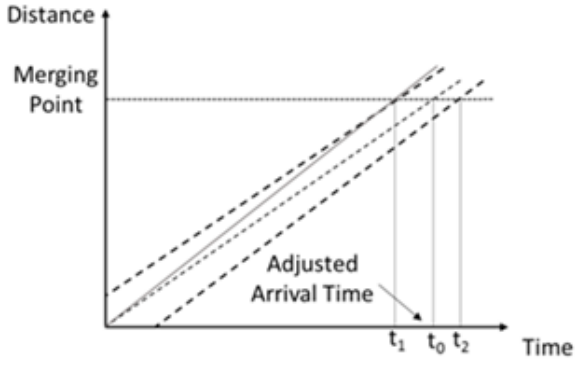
- Provides a moving vehicle on the ramp with a range of speed enabling the driver to enter the mainline in a safe manner
- Instantaneous information of vehicles on the mainline (e.g., speed, position, acceleration/deceleration rate
- Notification sent to driver typically 600-800 foot from merging point



Arrival Time Estimation



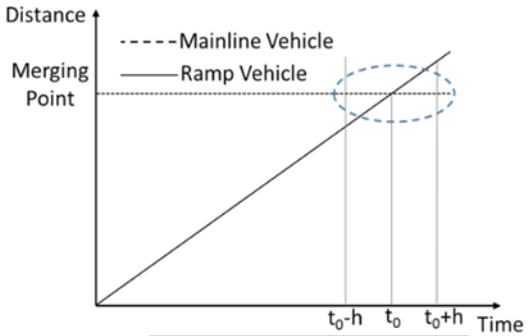




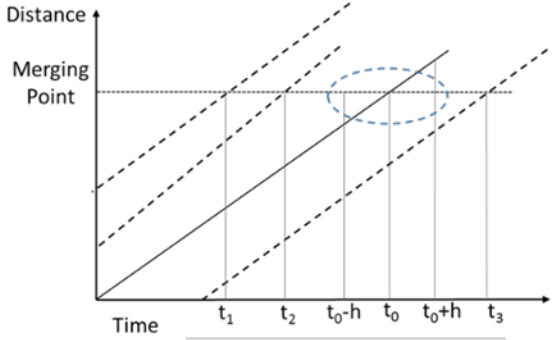
Advisory speed range is determined by taking into consideration:

- Safety headway
- Arrival times of mainline vehicles

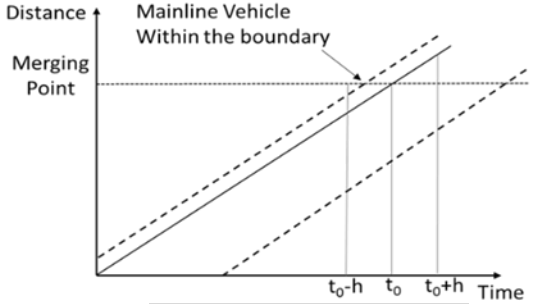
Advisory Speed Range Determination



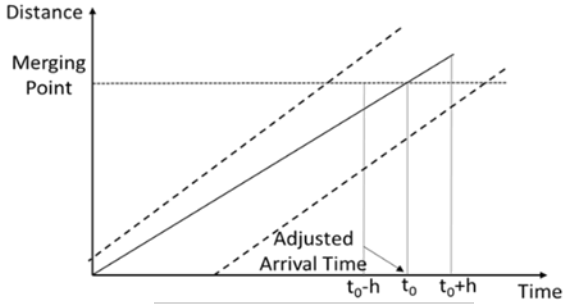
Safe Boundary



Safe Arrival

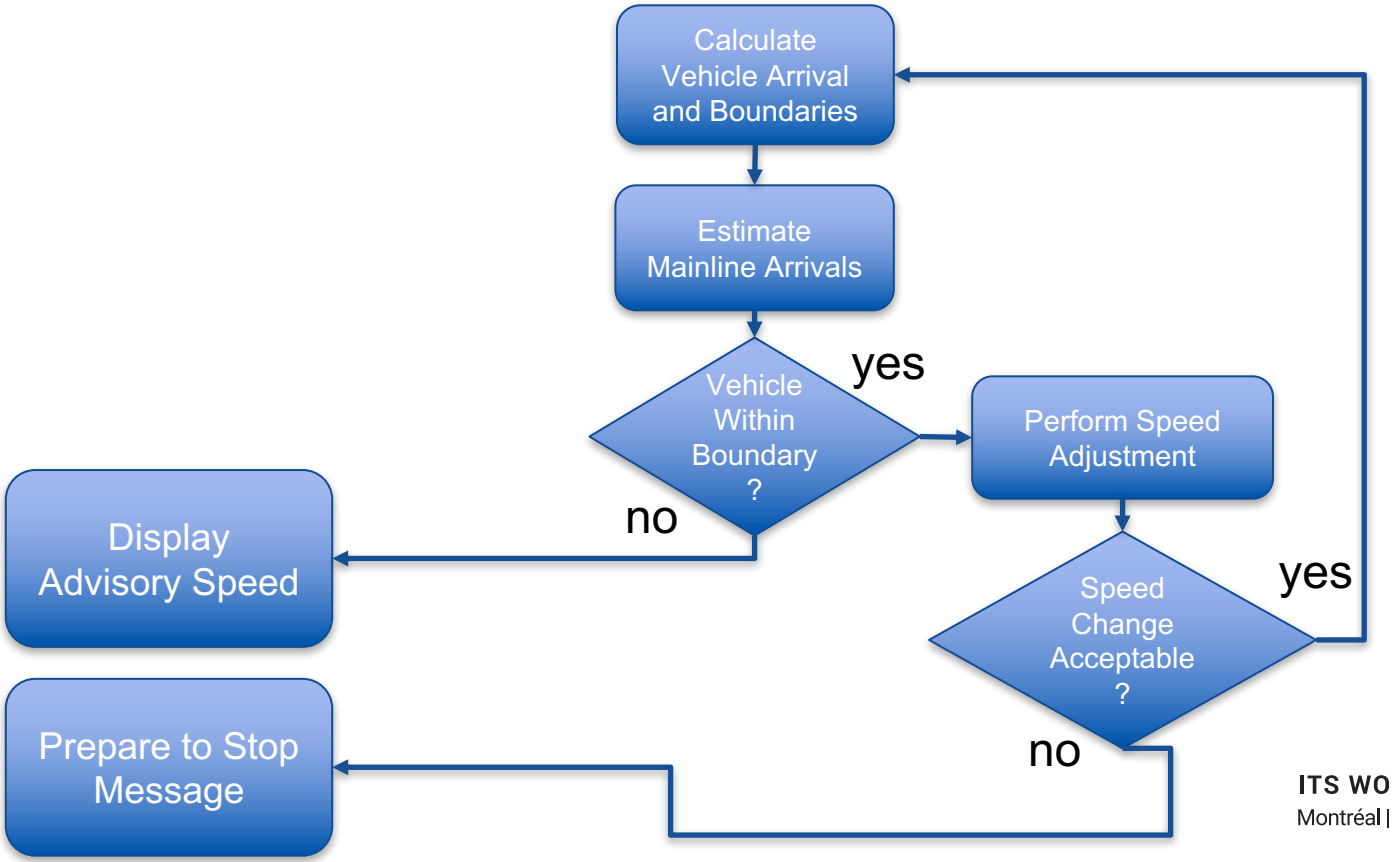


Unsafe Arrival

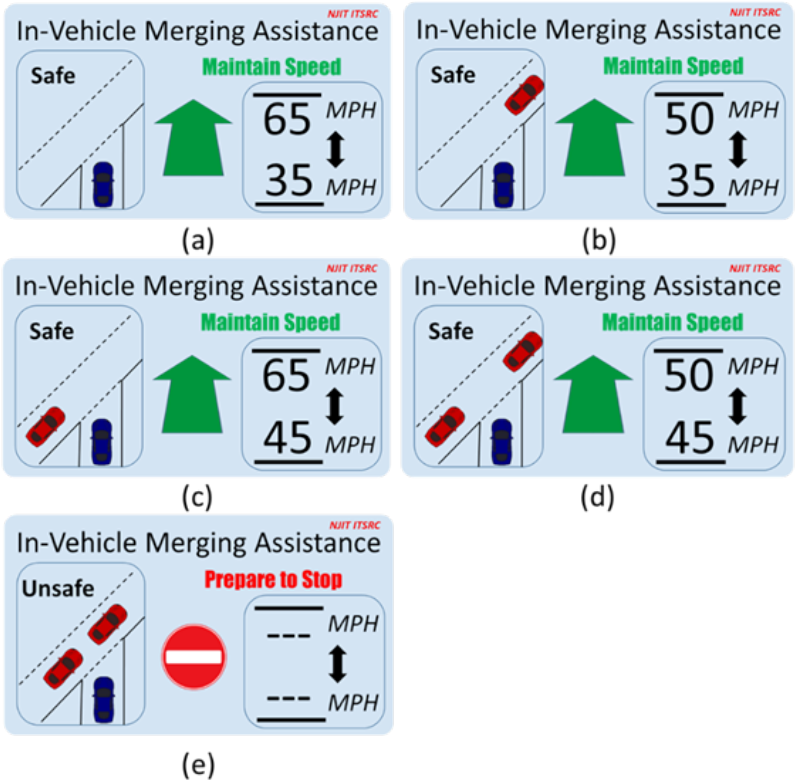


Adjusted Arrival

Control Algorithm



Cockpit Head-up Display (HUD)



a) No mainline vehicles (maintain speed limit)

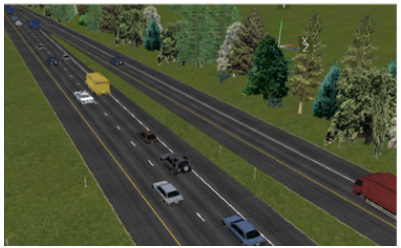
b) Vehicle in upper boundary

c) Vehicle in lower boundary

d) Vehicle in both boundaries

e) Prepare to stop

Experiments



- Traffic volume on the mainline between 1200 and 1800 vehicles/hour/lane
- 200-foot acceleration lane
- Ramp is likely to cause unsafe merging maneuvers from drivers due to:
  - ➢ Insufficient acceleration lane length
  - ➢ Difficulty to visually observe approaching vehicles

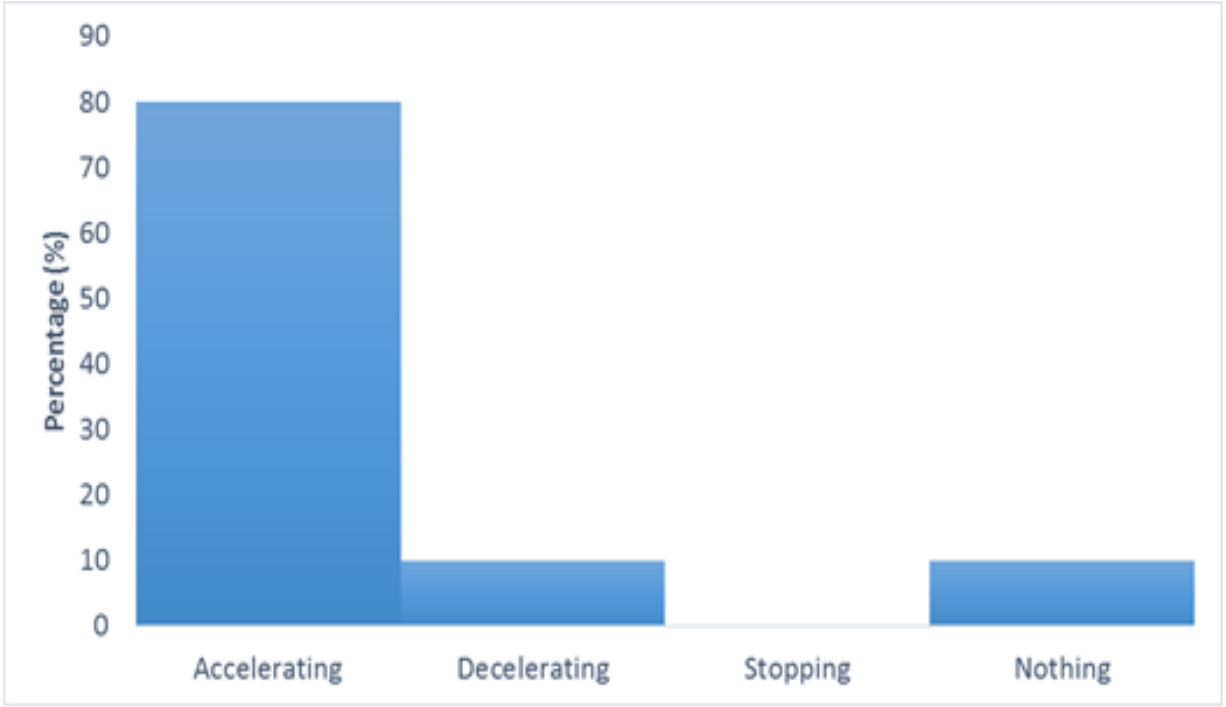
Results

- FSA application is examined by analyzing both quantitative and qualitative measures captured through questionnaire

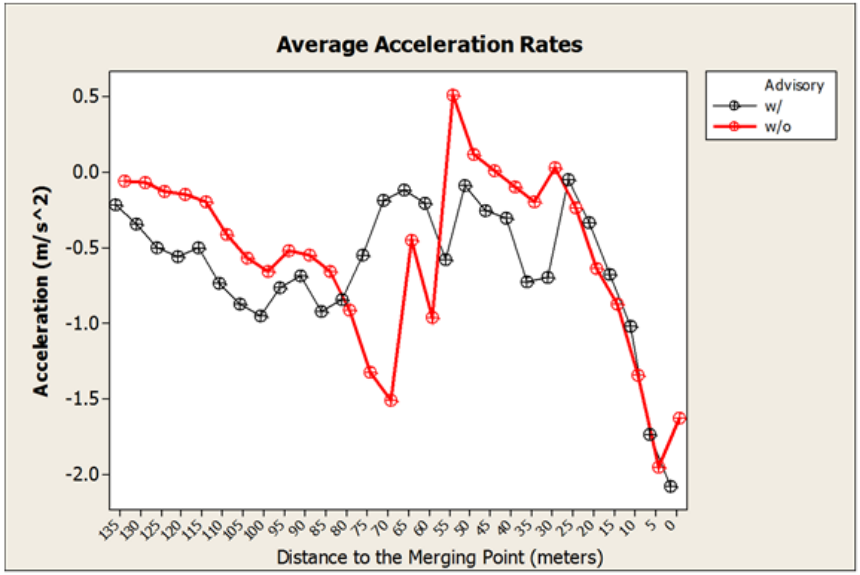
* 1 : Disagree Completely ☾ 5: Agree Completely (Percent)	1	2	3	4	5
A system to improve safety (e.g., avoid dangerous condition)	0	0	30	30	40
A system to improve mobility (e.g., delay/stop reduction)	0	0	30	30	40
A source of confusion or distraction	0	40	30	20	10
A useful driving assistance tool	0	30	10	20	40
Increasing mental (and visual) effort	0	20	20	40	20
Increasing driver comfort	30	30	10	30	0
Making the driver less vigilant	20	0	20	60	0
Making the driver less stressed	0	30	10	60	0
Unreliable in its operations	50	30	10	10	0
The information presented on the in-vehicle device was helpful	0	20	10	30	40

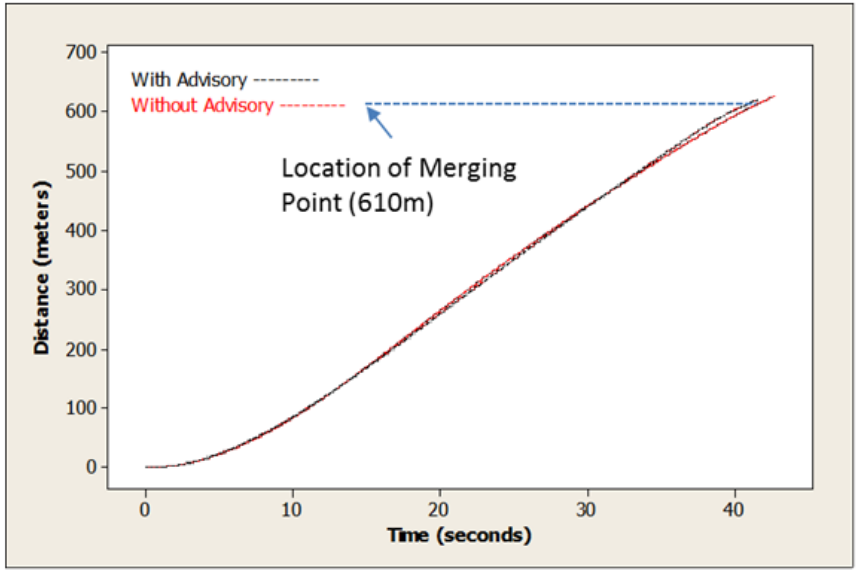
Results (Continued)

- Driver behavior impact



Results (Continued)





Concluding Remarks

- 70% of subject drivers complied the guidance information
- 60% of the subject drivers reported less stress
- 30% reported increased comfort
- 80% of compliance rate achieved during experiment
- 90% drivers reported to feel safe